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ABSTRACT

This study investigated aptitude-treatment interactions (ATI) in fourth, fifth, and sixth grade students' learning in large and small group teaching approaches. Each of two elementary teachers taught a two-week fractions unit to two classes of randomly assigned students. Each class received one approach. Students completed aptitude measures at the beginning of the study, and achievement, attitude, and retention measures at the end. Regression analyses showed significant ATI for preference for approach and for ability. Students who said they preferred small groups did worse in that approach than in the large-group approach. High ability students performed better and had more positive attitudes in the small group approach, and low ability students performed better and had more positive attitudes in the large group approach. High ability students benefited by "teaching" their peers in the small group. (Author/MP)

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INDIVIDUAL CHARACTERISTICS AND CHILDREN'S LEARNING IN LARGE-GROUP AND SMALL-GROUP APPROACHES

by

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Report from the Project on
Studies of Instructional Programming for the Individual Student

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Abstract

This study investigated aptitude-treatment interactions (ATI) in fourth-, fifth-, and sixth-grade students' learning in large- and small-group teaching approaches. Each of two elementary teachers taught a 2-week fractions unit to two classes of randomly assigned students. Each class received one approach. Students completed aptitude measures at the beginning of the study, and achievement, attitude, and retention measures at the end. Regression analyses showed significant ATI for preference for approach and for ability. Students who preferred small groups did worse in that approach than in the large-group approach. High ability students and low ability students did better and had more positive attitudes in the small-group and large-group approach, respectively. High ability students benefited by "teaching" their peers in the small group.

Individual Characteristics and Children's Learning

in Large-Group and Small-Group Approaches

Introduction

The purpose of the present study was to investigate aptitude-treatment interactions in children's learning in a large-group approach in which each child works alone and in a small-group approach in which each child works with other children. Rosenshine (in press, Note 1) has argued that students learn more when working in large-group settings than in small-group settings because large-group settings allow for more adult supervision, and students spend more time on task. However, the results of a recent study by Webb (Note 2) suggest that learning in small groups may depend on the individual characteristics or aptitudes of students in the group.[1]

In a laboratory setting, Webb randomly assigned high school students to work on mathematics problems either alone or in small groups with three other students. Some of the small groups were uniform in ability, and others were mixed in ability. Students were given both immediate and delayed posttests. Webb found that ability level within groups interacted with learning condition:

> Judging especially by delayed tests, high-ability students performed equally well after learning in mixed-ability groups or individually, and less well after learning in uniform-ability groups. For medium-

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[1] In this study "aptitude" refers to "any characteristic of a person that forecasts his probability of success under a given treatment" (Cronbach & Snow, 1977, p. 6).

> ability students, the order from best to worst conditions was uniform-ability grouping, individual learning, mixed-ability grouping. For low-ability students the order was mixed-ability grouping, individual learning, uniform-ability grouping. (Webb, Note 2, pp. 82-83)

Webb attributed these results to the roles students played in the group process. High ability students who actively taught other students, as often happened in mixed ability groups, showed excellent performance on the retention test. Low ability students who received coherent explanations, as often occurred in mixed ability groups, did better on the retention test than low ability students who did not receive clear explanations.

Webb also found that ability level of the group interacted with learning condition. Groups above the median on ability performed better on the delayed test after learning in the individual condition. Groups below the median on ability performed better on the delayed test after learning in the group condition.

The present study used measures of student ability and adaptations of the individual learning approach and the mixed-ability group approach from Webb (Note 2) to investigate fourth-, fifth-, and sixth-grade children's learning of fractions in a regular classroom setting. Since this was an exploratory study, additional aptitudes were included in the study to investigate other possible aptitude-treatment interactions suggested by recent research. Some research has suggested that students who have an internal locus of control do better in instructional approaches

where responsibility for learning is placed more on the children themselves than on the teacher (see, for example, Stone, 1974; Wright & DuCette, 1976). Other research (Peterson, 1977; Solomon & Kendall, 1976) has indicated that aptitudes such as anxiety and conformance vs. independence may interact with instructional approaches that differ in the amount of structure provided by the teacher and the amount of participation allowed by the students. Finally, many educators have argued that the best predictor of a student's performance with a particular teaching approach is the student's own stated preference for that approach. However, Cronbach and Snow (1977) reported that in the few studies testing this strategy, the results indicated that basing instructional adaptations on student preference did not improve learning and tended to be detrimental.

Method

Subjects

The setting was an elementary school in rural Wisconsin that practiced Individually Guided Education (IGE). (See, for example, Klausmeier, Rossmiller, & Saily, 1977.) In this school, approximately 100 students were assigned to multiage Instruction and Research (I and R) units that each had four teachers. Students from one fourth- and fifth-grade I and R unit and from one fifth- and sixth-grade I and R unit participated in this study with one female teacher from each unit. The teachers volunteered to participate in the study and were paid a small honorarium for their participation.

Each of the two teachers identified 50 to 55 students in her I and R unit who had the necessary preparation for fractions but had not learned the material to be taught. Informed consent of the parents was obtained for the students who participated in the study. A few students whose parents did not sign written consent forms were excluded from the study. Within the I and R unit, students were randomly assigned to one of two treatments--a large-group approach or a small-group approach. The resulting class sizes were 25 and 24 students in the small-group approach and 26 and 25 students in the large-group approach. Students in the small-group approach were further assigned to small groups of four students that varied in math ability. Students were stratified on ability using a bivariate distribution of their math achievement scores on the Sequential Tests of Educational Progress and their scores on Ravens Progressive Matrices. Students within each class were then randomly assigned so that

each group had one low ability student, one or two medium ability students, and one or two high ability students.

Instrumentation

The school regularly used a "continuous progress" approach to mathematics in which students worked on their own through a math unit until they could pass a mastery test and then moved on to the next unit. For the purpose of this study, students were taught with two teaching approaches that differed from the regular approach used, and students were taught a unit on common fractions from Developing Mathematical Processes (Wisconsin Research and Development Center, 1976), which was not their regular curriculum.

At the beginning of the study, students completed the following aptitude measures: Ravens Progressive Matrices (Cronbach's α reliability coefficient = .92); a 20-item version of the Intellectual Achievement Responsibility (IAR) locus of control scale by Crandall, Katkovsky, and Crandall (1965) (α = .54); the math anxiety scale by Fennema and Sherman (1976) (α = .83); a measure of conformance by Gordon (Note 3) (α = .87); an attitude toward math pretest (α = .89); and a preference for learning in small groups scale (α = .66). Students' scores on the Sequential Tests of Educational Progress (STEP) were obtained from the school and included as a measure of previous math achievement.

The IAR scale was scored so that a high score represented an internal locus of control, and a low score represented an external locus of control. The conformance measure was scored as follows: "Strongly agree" = 5, "agree" = 4, "I don't care" = 3, "disagree" = 2, and "strongly disagree" = 1. As stated by Gordon (Note 3), high scores on this measure "typify

the student who is accepting of and acquiescent to authority, who would prefer to have specific rules and guidelines to follow, who is disinclined to question expert judgment, and who seeks the security of institutional and group identification" (p. 1). The attitude toward math scale consisted of 15 items adapted from the Science Attitude Inventory developed by Klausmeier, DiLuzio, and Brumet (Note 4). The attitude scale had a 5-point Likert response format ranging from "strongly agree" to "strongly disagree." The preference for learning in small groups scale consisted of eight items. For each item, students were asked to choose either a statement describing the small-group approach or a statement describing the large-group depending on their preference. For example, "I would most like a math class where . . . (a) I work on problems with a small group of kids, or (b) I work on math problems by myself."

At the end of the 2-week unit on fractions, student achievement was assessed with a 35-item test on fractions that required the student to do computations and story problems with fractions. The test covered only material actually taught in class and was adapted from a test included as part of the curriculum unit (Wisconsin Reasearch and Development Center for Cognitive Learning, 1976). The same test was administered 2 weeks later to assess retention. Cronbach's α was .92 for the immediate test and .93 for the delayed test. At the end of the study, students also completed an attitude toward math posttest (α = .87) and an attitude toward teaching approach scale (α = .87). The attitude toward math scale was the same one that was administered as a pretest. The attitude toward teaching approach scale consisted of eight statements such as,

"I like the way my teacher taught math class." Students responded to these statements on a 5-point Likert scale from "strongly agree" to "strongly disagree."

An observation instrument was constructed to assess how accurately the two teaching approaches were implemented and to measure student behavior during class. The observation system required a coder to check the categories of behavior that occurred for each of four individual students and the teacher during each 20-second interval of classroom interaction. The coder observed four students for 10 minutes and then moved on to observe another four students for 10 minutes. One observer coded half the students in the class, and another observer coded the remaining students. Thus, all students were observed for 10 minutes each day. The order in which students were observed was counterbalanced so that during the study, each student was observed at various times during the class period.

The generalizability of the observations was assessed using the procedure described by Cronbach, Gleser, Nanda, and Rajaratnam (1972). An estimate of the generalizability of the observations across coders and days was obtained by having two coders observe each teacher teaching each approach on two days. Day was considered to be a fixed effect. The categories and their generalizability coefficients (ρ) given one coder were as follows: class works as whole group (ρ = .66); class works in small groups (ρ = .99); student explains to whole group (ρ = .77); student explains to another student in small group (ρ = .94); student

receives student explanation in small group (ρ = .96); student asks question of another student in small group (ρ = .82); student listens/observes as part of whole group (ρ = .99); student works quietly as part of whole group (ρ = .99); student works quietly in small group (ρ = .90); student is off-task as part of whole group (ρ = .59); student is off-task in small group (ρ = .58). These last two categories had the lowest generalizability coefficients probably because "off-task" behavior is difficult to define and code reliably.

Procedure

Several weeks before the study began, the experimenter met with the teachers to discuss the curriculum and the teaching approaches. The experimenter gave the teachers a short description of what the teacher would do in each approach. The experimenter also discussed in detail the objectives, content, and activities in the unit on fractions. The teachers then wrote two sets of lesson plans for each of 9 days of instruction--one set for each teaching approach. The lesson plans insured that the same content was covered in all classes and that the two teachers taught a given approach in the same way.

Two weeks before the study began, the students were given the aptitude tests. Also, students were informed that they would be participating in a study and that during the study they would not be using the regular math materials and "continuous progress" approach but rather, they would be using new workbooks and a different approach.

Each teacher taught the unit on fractions for 40 minutes per day to her two classes of students according to the approach to which the

class had been randomly assigned. Each teacher taught both apprcaches. In the large-group approach, the teacher proceeded as follows: The teacher introduced the material in the day's lesson to the whole group by explaining, asking questions of the class, and working problems on the board. The teacher then gave the workbook assignment, and each student worked on the workbook by him- or herself. The teacher monitored the work of individual students and gave help as needed. After students had finished, the teacher went over the correct answers to workbook pages by giving the answers or calling on students to give the answers. In the small-group approach, the teacher proceeded as follows: The teacher introduced the material in the day's lesson to the whole group by explaining, asking questions of the class, and working problems on the board. The teacher then gave the workbook assignment, and students worked on the workbook problems in their assigned group of four students. Each student wrote answers in his or her workbook, but students were told that they should get help from and talk with other students in their group as needed. Students were told to get help from others in the group before asking the teacher. The teacher monitored the work of small groups but only provided help when none of the students in the group could work the problem or answer a student's question. After students had finished, the teacher went over the correct answers to workbook pages.

In order to schedule the math classes during the regular school day, Teacher 1 taught the small-group approach to one class for 9 days while Teacher 2 taught the large-group approach to a second class for

9 days. Then Teacher 1 taught the large-group approach to a third class for 9 days while Teacher 2 taught the small-group approach to a fourth class for 9 days. Teacher 1 was absent for 2 days during the study, and her classes were taught by Teacher 2 during this time.

During the study, observers coded classroom interaction using the observation system described above. Observers also noted whether or not a student was absent from class. At the end of the 9-day unit, students completed the achievement test, the attitude toward math scale, and the attitude toward teaching approach scale. Two weeks later students were given the same achievement test to assess retention. Students did not receive feedback on the correct answers to the test between the first test and the delayed test.

Aptitude and outcome measures were computer-scored and item analyses were performed using Fortap (Baker, Note 5). Generalizability analyses on the observation instrument were done with BMD: Biomedical Computer Programs (Dixon, 1971). All other statistical analyses were performed with SPSS: Statistical Package for the Social Sciences (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975).

Results

Fidelity of Implementation of Teaching Approaches

Table 1 presents the means and standard deviations for each observation category in the four classes. Each mean represents the average number of intervals coded per day for students in that class. Observations were first averaged across 9 days for each student, and then an average was obtained for students in each class. A total of 30 20-second intervals were coded for a student each day. The frequencies for all categories do not sum to 30 because more than one category often occurred during a 20-second interval of classroom interaction.

The means in Table 1 indicate that the teaching approaches did differ as intended. In the large-group approach, students did not work in small groups and the following categories never occurred: class in small groups; student explains in small group; student receives student explanation in small group; student asks question of student in small group; student works quietly in small group; and student off-task in small group. The two classes in the small-group approach had similar means for the above categories except in two cases. Observers coded more intervals in Class 2 than in Class 1 for "works quietly in small group," and more intervals in Teacher 1's class than in Teacher 2's class for "off-task in small group." As intended in the small-group approach, students in the small-group classes spent time working as a whole group, and observations occurred in the whole-group categories. The two classes in the large-group approach had similar means for the whole-group categories except for "off-task in

Table 1

Mean Number of Intervals Coded in the Observation Categories for Students in the Four Classes (Standard Deviations in Parentheses)

	Small-group approach		Large-group approach	
Class of teacher:	1	2	1	2
Observation category	(N = 24)	(N = 25)	(N = 25)	(N = 26)
Class as whole group	16.20	15.68	26.06	25.30
	(3.16)	(3.24)	(1.57)	(1.86)
Class in small groups	9.58	8.97	0.00	0.00
	(3.51)	(1.70)	(0.00)	(0.00)
Student explains to whole group	1.44	0.71	1.13	0.95
	(1.17)	(0.61)	(0.60)	(0.49)
Student explains in small group	1.62	1.95	0.00	0.00
	(1.47)	(2.08)	(0.00)	(0.00)
Student receives student explanation in small group	1.20	1.95	0.00	0.00
	(0.96)	(2.01)	(0.00)	(0.00)
Student asks question of student in small group	0.94	0.83	0.00	0.00
	(0.76)	(0.83)	(0.00)	(0.00)
Student listens/observes in whole group	17.96	15.94	23.22	23.51
	(2.79)	(3.67)	(1.54)	(2.60)
Student works quietly in whole group	0.50	0.04	4.68	5.25
	(0.81)	(0.07)	(1.45)	(2.68)
Student works quietly in small group	5.98	11.00	0.00	0.00
	(2.07)	(1.43)	(0.00)	(0.00)
Student off-task in whole group	0.47	0.02	1.09	0.24
	(0.38)	(0.08)	(0.99)	(0.32)
Student off-task in small group	1.07	0.28	0.00	0.00
	(1.37)	(0.24)	(0.00)	(0.00)

whole group." Again, Teacher 1's class had more off-task behavior than Teacher 2's class.

Descriptive Statistics on Aptitudes and Outcomes

Table 2 shows the means and standard deviations of the aptitude and outcome scores of students in all classes. Means and standard deviations of the aptitude scores were similar across the four classes. Students' aptitude toward math decreased slightly from pretest to posttest. Mean scores on the achievement test remained about the same when retention was assessed 2 weeks after the posttest.

Pooled within-class correlations were calculated between aptitude scores and between outcome scores. Students' scores on STEP-math concepts were highly correlated with scores on STEP-math computation (r = .65). Furthermore, scores on Ravens Progressive Matrices were positively correlated with scores on math concepts (r = .52) and scores on math computation (r = .48). Not surprisingly, students' scores on the attitude toward math pretest were negatively correlated with scores on anxiety about math (r = -.53). Scores on the achievement posttest were highly correlated with scores on the retention test (r = .90).

Principal-Component Analysis of Aptitudes

In order to approximate the factor score for ability used by Webb (Note 2) and also because students' scores on several aptitudes were highly correlated, a principal-component analysis was performed on the aptitude scales. Varimax rotation was used. Two factors were requested, and two factors emerged from the analysis. The first factor was an ability factor similar to the ability factor in the Webb study. STEP math concepts, STEP math computation, and Ravens Progressive Matrices loaded .82, .79, and .59,

Table 2

Means and Standard Deviations of Aptitudes and Outcomes

(Standard Deviations in Parentheses)

	Small-group approach		Large-group approach	
Class of teacher:	1	2	1	2
Variable	(N = 24)	(N = 25)	(N = 25)	(N = 26)
STEP-math concepts	24.75	26.80	24.40	28.58
	(7.75)	(7.09)	(7.52)	(7.45)
STEP-math computation	30.79	30.92	31.12	32.15
	(6.92)	(7.82)	(8.70)	(8.67)
Ravens Progressive Matrices	40.08	35.28	35.80	40.42
	(6.20)	(11.09)	(10.68)	(9.08)
Attitude Toward Math pretest	55.21	51.80	53.76	49.69
	(9.24)	(10.46)	(8.97)	(7.94)
Math anxiety	26.37	30.08	27.04	27.96
	(8.45)	(8.10)	(6.84)	(4.93)
Conformance	78.87	78.24	80.84	78.38
	(11.27)	(15.08)	(15.19)	(11.26)
Locus of control	14.37	14.68	14.16	14.54
	(2.06)	(2.58)	(2.21)	(3.76)
Preference for learning in small groups	3.25	3.08	3.20	3.54
	(1.75)	(2.00)	(2.33)	(2.23)
Achievement posttest	18.96	20.28	20.96	21.42
	(7.53)	(9.39)	(10.62)	(7.80)
Retention test	18.33	18.96	20.64	22.23
	(8.35)	(10.60)	(10.73)	(7.35)
Attitude toward math posttest	53.75	48.68	52.68	47.42
	(9.73)	(7.95)	(5.21)	(8.14)
Attitude toward teaching approach posttest	23.71	25.92	22.64	28.50
	(7.58)	(4.91)	(7.11)	(4.31)

respectively, on the first factor. Conformance loaded -.40 on the first factor. The second factor was an attitude/anxiety toward math factor. The attitude toward math pretest loaded .78 on this factor, and math anxiety loaded -.72. These factors were used in the regression analyses. Since locus of control and preference for learning in small groups did not load on either factor, they were entered in the regression analysis as separate aptitudes.

Aptitude-Treatment Interaction (ATI)

Generalized regression analyses were performed on achievement and attitude scores to test for ATI. As suggested by Cronbach and Snow (1977), deviation scores were used for the aptitudes in the regression analysis, and effect coding (-1 and +1) was used for the treatments. Although Cronbach and Snow (1977) describe a step-up procedure for testing ATI, Cronbach (Note 6) has recommended a procedure in which the variance accounted for (R^2) and F ratios for a variable or group of variables are calculated by stepping down from the full regression model to a model without that variable or group of variables in the equation. Such a procedure was used here.

Aptitudes, teacher, and treatment were entered into the equation. All first-order ATI were entered and, in addition, ATI terms for ability x attitude/anxiety and $(\text{ability})^2$ were included. Past research has shown curvilinear ATI for ability (Webb, Note 2) and significant ATI for ability x anxiety (Cronbach & Snow, 1977; Peterson, 1977, in press).

Effects of aptitudes, teacher, treatment, and ATI were tested at a less conventional significance level of .10 because of the lack of

statistical power in the present study. Cronbach and Snow (1977) have stated that to have adequate power to detect ATI, a study must have at least 100 subjects per treatment. In the present study, it would have been impossible to have more than 25 to 30 students per class because class size is mandated by teachers' unions and because the teaching approaches could not have been implemented appropriately with more students.

Two sets of analyses were performed. In the first set, the individual student was the unit of analysis. In the second set, the group of four students was the unit of analysis. For the purposes of the second analysis, groups of four students were formed within each of the two classes in the large-group approach. Each group in the large-group approach was matched on ability to a group in the small-group approach taught by the same teacher. Groups in the large-group approach were used only for the analysis, and students were never instructed in these groups during the study.

ATI with the student as unit of analysis. Table 3 presents the results of the regression analyses on retention scores, attitude toward math posttest scores, and attitude toward teaching approach posttest scores. The results of the regression analysis on achievement scores are not presented because only ability (factor 1) contributed significantly to the prediction of achievement scores, F (1,84) = 102.33, $p < .01$. Treatments, ATI, and other aptitudes did not add significantly to the prediction of achievement scores.

The full regression equation accounted for 66.4% of the variance in scores on the retention test. Ability accounted for the largest proportion of the variance (51.4%) in retention scores. Neither teacher

Table 3

Summary of Regression Analyses with the Student as the Unit of Analysis

Variable in regression	df	Retention test		Attitude toward math		Attitude toward approach	
		R^2	F	R^2	F	R^2	F
Full model	15	.667	11.23***	.631	9.58***	.305	2.46***
All aptitudes	6	.606	25.48***	.463	17.57***	.074	1.49
Ability (Ab)	1	.514	129.72***	.000	0.03	.001	0.18
Attitude/Anxiety (Att/Anx)	1	.002	0.54	.400	91.03***	.024	2.87*
Locus of control	1	.008	2.07	.019	4.32**	.004	0.54
Preference	1	.006	1.50	.004	0.90	.012	1.46
Ability x Att/Anx	1	.000	0.08	.001	0.24	.002	0.28
$(Ability)^2$	1	.000	0.00	.002	0.43	.003	0.40
Teacher and treatment	3	.002	0.17	.014	1.06	.156	6.28***
Teacher	1	.000	0.08	.011	2.52	.096	11.66***
Treatment	1	.001	0.19	.002	0.55	.039	4.72**
Teacher x Treatment	1	.000	0.28	.000	0.08	.016	1.99
All ATI	6	.032	1.34	.030	1.14	.119	2.40**
Ability x Treatment	1	.014	3.49*	.012	2.78*	.008	0.96
Att/Anx x Treatment	1	.001	0.17	.000	0.05	.000	0.01
Locus x Treatment	1	.002	0.51	.004	0.85	.003	0.40
Preference x Treatment	1	.020	5.10**	.001	0.20	.013	1.60
Ab x Att/Anx x Treatment	1	.001	0.17	.004	0.97	.047	5.70**
$(Ability)^2$ x Treatment	1	.004	0.94	.001	0.23	.044	5.27**
Residual	84	.333		.369		.695	

*$p < .10$.

**$p < .05$.

***$p < .01$.

nor treatment alone significantly predicted retention scores, but ATI for ability and preference did. These ATI were examined by computing the regression equation for each treatment from the unstandardized regression coefficients. These equations are presented in Table 4.

As can be seen from Table 4, high ability students retained more in the small-group approach than in the large-group approach, and low ability students retained more in the large-group approach than in the small-group approach. Students who initially preferred the small-group approach actually did worse on the retention test in that approach and did better in the large-group approach. Students who initially preferred the large-group approach did worse in that approach and did better in the small-group approach.

Students' attitude toward math was best predicted by their initial attitude toward math. Students who had a positive attitude toward math at the beginning of the unit had a positive attitude at the end of the unit, while students who had a negative attitude at the beginning had a negative attitude at the end of the unit. Locus of control also predicted students' attitude toward math. Internal students tended to have a negative attitude toward math, and external students had a positive attitude. Again, treatment and teacher were not statistically significant, but a significant ATI for ability appeared. ATI for ability followed the pattern described above for the retention test. High ability students had a more positive attitude in the small-group approach than in the large-group approach. Low ability students had a more positive attitude in the large-group approach than in the small-group approach.

As shown in Table 3, the full regression model accounted for 30.5%

Table 4

Regression Equations for Analyses with the Student as the Unit of Analysis

Dependent variable and treatment	Constant	b for ability (ab)	b for attitude/ anxiety (att/anx)	b for locus of control	b for preference	b for ab x att/anx	b for $(\text{ability})^2$
Retention test							
Small-group approach	19.63	9.85	-.99	-.18	-1.21	.53	-.75
Large-group approach	20.35	7.07	-.27	-.56	.35	-.09	.69
Attitude toward math							
Small-group approach	51.63	1.03	7.76	-.72	.45	-.34	-.78
Large-group approach	50.47	-1.27	7.42	-.28	.17	1.02	-.12
Attitude toward approach							
Small-group approach	23.89	.41	1.35	-.35	-.86	1.38	1.22
Large-group approach	27.51	-1.03	1.53	-.03	.02	-2.16	-2.16

of the variance in students' attitude toward the teaching approach. Teacher and treatment accounted for 15.6% of the variance, and ATI accounted for 11.9% of the variance. Students' attitude toward math was related to their attitude toward the teaching approach, but students' initial preference for an approach was unrelated to their final attitude toward the approach. Overall, students had a more positive attitude toward the teaching approach in the large-group approach and in Teacher 2's classes. Significant ATI for ability x attitude/anxiety indicated that high ability-high attitude/low anxiety students and low ability-low attitude/high anxiety students had a more positive attitude in the small-group approach. High ability-low attitude/high anxiety and low ability-high attitude/low anxiety students had a more positive attitude in the large-group approach. Finally, curvilinear ATI for ability showed that high and low ability students had a more positive attitude toward the teaching approach in the small-group approach. Medium ability students had a more positive attitude in the large-group approach.

ATI with the group as the unit of analysis. The results of the regression analysis with the group as the unit of analysis showed that the full regression equation did not significantly predict scores on the achievement test, the retention test, or attitude toward teaching approach. However, the full model accounted for 94.3% of the variance in attitude toward math and was statistically significant, F (15,8) = 8.85, $p < .001$. The best predictor of a group's attitude toward math at the end of the unit was the group's initial attitude toward math, F (1,8) = 33.61, $p < .001$. Other significant aptitudes were locus of control, F (1,8) = 12.26, $p < .001$, and

preference for an approach, F (1,8) = 4.67, $p < .10$. Groups with an external locus of control had a more positive attitude toward math than groups with an internal locus of control. Groups who initially preferred a small-group approach had a more positive attitude than groups who initially preferred a large-group approach.

Teacher and treatment did not contribute significantly to the prediction of groups' attitude, but ATI did. Significant ATI appeared for locus of control, F (1,8) = 6.84, $p < .05$; preference for approach, F (1,8) = 7.32, $p < .05$; and ability x attitude/anxiety, F (1,8) = 3.72, $p < .10$. Groups that were internal on locus of control had a more positive attitude toward math in the large-group approach; groups that were external had a more positive attitude in the small-group approach. Groups that initially preferred a small-group approach had a more positive attitude toward math in that approach, and groups that preferred a large-group approach had a more positive attitude in the large-group approach. High ability-high attitude/low anxiety groups and low ability-low attitude/high anxiety groups had a more positive attitude toward math in the large-group approach. High ability-low attitude/high anxiety groups and low ability-high attitude/low anxiety groups had a more positive attitude in the small-group approach.

Observations of Group Processes

In order to attempt to explain the processes behind the ATI effects, the observation data were examined. Within each treatment, students' scores on the observation variables were correlated with their scores on aptitudes and outcomes.

Since off-task behavior was the most salient indicator that the student was not engaged in learning, correlations with off-task behavior were examined to determine if students with certain aptitudes spent more time off-task in one approach and if off-task behavior was related to students' scores on the retention and attitude tests. Within the small-group approach, students' off-task behavior while working in small groups was negatively related to their scores on the retention test ($r = -.26$, $p < .05$) and to their scores on attitude toward teaching approach ($r = -.30$, $p < .05$) but was unrelated to scores on attitude toward math ($r = -.04$). Furthermore, aptitude scores were found to be unrelated to off-task behavior. Within the large-group approach, off-task behavior was unrelated to scores on the retention test ($r = -.04$) and attitude toward teaching approach ($r = .05$) but was positively related to students' attitude toward mathematics ($r = .37$, $p < .01$). The only significant relationship between aptitudes and off-task behavior was a positive correlation between attitude/anxiety and off-task behavior ($r = .37$, $p < .01$).

Since correlations with off-task behavior did not explain the ATI effects, correlations with observation variables similar to the group process variables used by Webb (Note 2) were examined. Webb looked at the number of times a student explained to or actively taught another student in the small group and the number of times a student received an explanation from another student. In the present study, the number of intervals a student spent explaining to another student in the small group was positively related to scores on the retention test ($r = .29$,

$p < .05$) and the attitude toward math posttest ($r = .22$, $p < .06$). Furthermore, high ability students did more explaining than low ability students ($r = .38$, $p < .01$). Surprisingly, receiving an explanation from another student in the small group was unrelated to ability or to subsequent scores on the retention test and the attitude toward math posttest. Within the large-group approach, the number of intervals a student spent explaining to the whole group was positively related to scores on the retention test ($r = .28$, $p < .05$) and the attitude toward math posttest ($r = .23$, $p < .05$). These explanations to the whole group usually occurred as a result of the teacher calling on a student to answer a question. Ability was unrelated to the number of intervals a student spent explaining to the whole group.

Discussion

Several important findings emerged from this study. First, on the average, students in the large-group approach and students in the small-group approach did equally well on the achievement test at the end of the unit and on the retention test 2 weeks later. Thus, these results contradict Rosenshine's (in press) assertion that students learn more when working in large-group settings than in small-group settings.

Although neither the large-group approach nor the small-group approach was more effective for all students, some types of students did better on the delayed test in the large-group approach while other types of students did better in the small-group approach. As in the Webb (Note 2) study, significant ability x treatment interaction effects appeared for students' performance on the delayed test. However, Webb found a curvilinear ATI for ability. High ability students did equally well after learning individually or in mixed-ability groups; medium ability students did better after learning individually; and low ability students did better after learning in mixed-ability groups. In the present study, high ability students did better on the delayed test in the small-group approach, and low ability students did better on the delayed test in the large-group approach.

Two important differences between the two studies may be responsible for the diverse results. First, the studies employed students at two different grade levels. Webb used high school students, and the present study used fourth-, fifth-, and sixth-grade students. Second, the

"large-group" approach in the present study does not really correspond to the "individual" treatment in the Webb (Note 2) study. In the individual treatment students worked alone without direction or assistance. In the large-group approach students worked alone but were given direction and assistance by the teacher as needed. For low ability students who probably need more direction and assistance, the mixed-ability group would provide more assistance than the individual treatment in the Webb study. On the other hand, in the present study the large-group approach would probably provide more direction than the small-group approach.

Despite differences between the two studies, the group process variables noted by Webb help explain the ATI for ability in the present study. High ability students often explained to other students in their small group. These explanations usually consisted of helping another student with a workbook problem or "teaching" the other student how to work a certain kind of problem. Apparently, these explanations benefited the giver of the explanation but did not necessarily help the receiver. Thus, high ability students learned much about fractions by explaining the material to other students in their group. Similar results have been reported for studies of tutoring (see, Allen & Feldman, 1973; Cloward, 1976). For example, in a 2-week study by Allen and Feldman (1973), tutors either taught a younger child or spent the equivalent amount of time studying alone. Tutees either were taught by an older child or studied alone. Tutors initially learned more when studying alone than when tutoring, but by the end of the 2-week period, tutoring was producing

better learning than studying alone. Initially the tutees learned more when being taught, but by the end of the 2 weeks, they did slightly better when studying alone. These results together with the results of the present study suggest that teaching or tutoring benefits the tutor more than the tutee.

Why did low ability students do better on the delayed test in the large-group approach? Low ability students probably needed the greater direction and help provided by the teacher in the large-group approach. They did not know the material well enough to be able to explain it to other students in their small group. Therefore, they did not benefit by interacting with other students in their small group.

Another important finding appeared for students' preference for teaching approach. Many educators have argued that students should be assigned to the teaching approach that they prefer because students are the best judges of their own learning style. The present results indicate that students who, before the study, said they preferred learning in a small-group approach actually did worse on the delayed test in that approach and better in the large-group approach. Students who said they preferred a large-group approach actually did worse in that approach and better in the small-group approach. Perhaps students initially preferred the approach in which they thought they would have to work less hard. Surprisingly, students' attitude or liking for the teaching approach was unrelated to their initial preference. These findings support Cronbach and Snow's (1977) conclusion that assigning students to the instructional

approach they prefer does not improve learning and tends to be detrimental.

At the end of the study, students' attitude toward mathematics on the average was equally positive in the small-group and large-group approaches. However, high ability students had a more positive attitude in the small-group approach than in the large-group approach. Low ability students had a more positive attitude in the large-group approach than in the small-group approach. These findings follow the pattern described above for the delayed test. High ability students probably liked math better in the small-group approach because they were actively involved in explaining the math problems and helping others in their group with the math problems. Low ability students probably liked mathematics better in the large-group approach because the teacher provided direction and help, and they understood and liked the subject matter better as a result.

Students' attitude toward the teaching approach was related to their initial attitude toward math but was unrelated to their initial preference for an approach. Students had a more positive attitude toward the teaching approach in the large-group approach than in the small-group approach. In addition, a significant main effect for teacher appeared. This was the only significant teacher effect in the study. Finally, significant ATI appeared for ability x attitude/anxiety, and a significant curvilinear effect emerged for ability. These ATI are complex and difficult to interpret, but these results do indicate the importance of investigating possible higher-order ATI for ability.

The results with the group as the unit of analysis differed substantially from the results with the individual student as the unit of analysis. The full regression model including aptitudes, treatment, teacher, and ATI did not significantly predict groups' scores on the achievement test, delayed test, or attitude toward teaching approach scale but did significantly predict groups' scores on the attitude toward mathematics scale. Significant ATI were found for locus of control, preference for approach, and ability x attitude/anxiety. Groups that were internal on locus of control had a more positive attitude toward math in the large-group approach, while groups that were external on locus of control had a more positive attitude toward math in the small-group approach. Perhaps students in groups that were high on external locus of control tended to place the responsibility for their learning on persons and events outside themselves. Thus, the group tended to have a more positive attitude toward math when group members could look to each other for help in math rather than relying only on themselves. On the other hand, students in groups that were high on internal locus of control would tend to place the responsibility for learning on themselves. Internal groups would therefore have a more positive attitude when group members worked alone as in the large-group approach.

ATI for preference for approach and for ability x attitude/anxiety showed an opposite pattern to those found on the delayed test and on the attitude toward teaching approach scale, respectively, with the student as the unit of analysis. These results underscore the points made by Cronbach and Webb (1975) and Cronbach (Note 7) that an ATI analysis with

the group as the unit may produce results different from an analysis with the student as the unit, and that these two types of analyses answer psychologically different questions. For example, in the present study individual students did worse on the delayed test in the approach they initially preferred, but small groups had a better attitude toward math when assigned to the approach they preferred. To explain the former result one would have to speculate about psychological processes within the individual, and to explain the latter result one would have to speculate about psychological processes within the small group.

What is the practical importance of the findings in this study? Based on the results of this study, one can estimate how much a student's achievement and attitude would be improved by assigning the student to the more appropriate rather than the less appropriate teaching approach. For example, if students with ability scores one standard deviation above the mean were assigned to a small-group approach rather than a large-group approach, their retention test scores would be .19 standard deviations higher and their attitude scores would be increased by .39 standard deviations. Similarly, if students with ability scores one standard deviation below the mean were assigned to a large-group approach rather than a small-group approach, their retention test scores would be increased by .35 standard deviations and their attitude scores would be improved by .11 standard deviations. Since in this sample, approximately 19% of the students had ability scores at least one standard deviation above the mean, and 18% had ability scores one standard deviation below the mean, 37% of the students would be expected to improve their retention test

scores by at least .19 standard deviations and their attitude scores by .11 standard deviations or more by judicious assignment to treatment. Moreover, students with ability scores two standard deviations above the mean on ability would improve their retention scores by .46 standard deviations and their attitude scores by .65 standard deviations by being assigned to the appropriate treatment. Students two standard deviations below the mean would improve their retention test scores by .62 standard deviations and their attitude scores by .37 standard deviations.

If student preferences for teaching approach were used as a basis of assignment, certain students who initially preferred the small-group approach would be assigned to the large-group approach and other students who initially preferred the large-group approach would be assigned to the small-group approach. By this assignment, students one standard deviation above the mean on the preference scale would increase their retention test scores by .42 standard deviations, and students one standard deviation below the mean would improve their scores by .27 standard deviations. Furthermore, students two standard deviations above or below the mean on the preference scale would improve their retention test scores by .7o and .90 standard deviations, respectively. Since 40% of the students had preference scores at least one standard deviation above or below the mean, and 7% had preference scores at least two standard deviations above or below the mean, a large percentage of students would be expected to improve their scores substantially by appropriate assignment to treatment.

In conclusion, the results of the present study provide some

information on how individual characteristics and group process variables are related to children's learning in large-group and small-group approaches. They also indicate that students' achievement and attitude can be improved by adapting instruction to the needs of the individual student. Since no one teaching approach was found to be best for all students, these results suggest that educators need to provide for planning and implementing instruction suitable for the individual student.

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